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Patterns of routine primary care for osteoarthritis: a cross-sectional electronic health records study

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Abstract

Objective

To determine common patterns of recorded primary care for osteoarthritis (OA), and

characteristics associated with the quality of recorded care.

Design

An observational study nested within a cluster-randomised controlled trial.

Setting

Eight UK general practices who were part of the Management of OSteoArthritis In ConsultationS

(MOSAICS) study.

Participants

Patients recorded as consulting within the eight general practices for clinical OA.

Primary outcomes

Achievement of seven quality indicators of care, recorded through an electronic template or

routinely recorded in the electronic healthcare records, were identified for patients aged ≥45 years

consulting over a six-month period with clinical OA. Latent class analysis was used to cluster

patients based on care received. Clusters were compared on patient and clinician-level

characteristics.

Results

1724 patients consulted with clinical OA. Common patterns of recorded quality care were: Cluster 1

(38%, *High*) received most quality indicators of care; Cluster 2 (11%, *Moderate*) had pain and

function assessment, and received or were considered for other indicators; Cluster 3 (17%, *Low*)

had pain and function assessment, and received or were considered for paracetamol or topical

NSAIDs; Cluster 4 (35%, *None*) had no recorded quality indicators. Patients with higher levels of

recorded care consulted a clinician who saw more OA patients, consulted multiple times, and had

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46   less morbidity. Those in the *High* cluster were more likely to have recorded diagnosed OA and have

47   knee or hip OA.

48   **Conclusions**

49   Appropriate delivery of core interventions and relatively safe pharmacological options for OA are

50   still not consistently recorded as provided in primary care. Further research to understand clinical

51   recording behaviours and determine potential barriers to quality care alongside effective training

52   for clinicians is needed.

53   **Trial registration** number ISRCTN06984617

54   **Keywords**

55   Osteoarthritis, primary care, quality indicators, latent class analysis

56   **Article summary**

57   • This paper describes a novel use of latent class analysis to identify patterns of primary care

58   for osteoarthritis (OA)

59   • The population studied was large and diverse, increasing generalisability, and based on a

60   broad definition of clinical OA to reduce selection bias

61   • The analysis used some quality indicators of care newly-implemented in practices through

62   an electronic template, which may have increased the recorded quality of care compared to

63   routine practice

64   • Some care processes may have occurred but not been recorded

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66   **Word count** 3424

67 **Introduction**

68 Osteoarthritis (OA) is a common reason for adults aged ≥45 years to consult primary care. Annually,

69 in the UK, 4% of such adults are recorded as consulting in general practice for diagnosed OA, with

70 an additional 8% recorded with joint pain likely to be attributable to OA [1]. Osteoarthritis is a

71 common reason for disability, and was ranked the 11th biggest cause of disability by the 2010

72 Global Burden of Disease (GBD) [2].

73 The UK National Institute for Health and Care Excellence (NICE) OA management guidelines

74 recommend core strategies of information provision, physical activity and exercise, and weight

75 management, supplemented with use of relatively safe pharmacological management strategies

76 (for example, topical non-steroidal anti-inflammatory drugs [NSAIDs]), as necessary [3].

77 Intensification of management should depend on response to these initial approaches. However,

78 there is evidence that patients diagnosed with OA do not receive care that is well aligned to

79 evidence-based recommendations and which may be overly dependent on pharmacological

80 methods [4].

81 We have previously identified variation between clinicians in recorded quality of individual

82 indicators of OA care [5]. However, patterns of OA care and factors linked with increased

83 probability of adherence to OA quality standards are less well-studied. Using electronic general

84 practice records data, the objectives of this study were to determine patterns of recorded primary

85 care for OA based on quality indicators, and to determine associations between higher-quality

86 recorded care and patient and clinician characteristics.

87 **Methods**

88 This analysis used data from the Management of OSteoArthritis In ConsultationS (MOSAICS) study

89 (Trial registration number ISRCTN06984617), approved by the North West Research Ethics

90   Committee, Cheshire (reference: 10/H1017/76) [6]. MOSAICS was a mixed-methods study, which

91   investigated the effect of a model consultation for clinical OA. It was set within eight general

92   practices in Cheshire, Shropshire and Staffordshire, UK and is reported in line with STROBE

93   guidelines. The current analysis used anonymised information from the electronic health records

94   (EHR) of these practices for the six-month baseline period before randomisation of practices to

95   intervention or control arms [6]. At the beginning of the baseline period, a computerised template

96   ("e-template", described below) was installed within the EHR and all practices continued with

97   otherwise usual care until the end of the baseline period.

98   The study population was all patients aged ≥45 years registered with the eight general practices

99   who consulted with clinical OA in the baseline six-month period. UK general practice utilises Read

100   codes to record morbidities; within MOSAICS, clinical OA was defined as either a recorded OA Read

101   code or a peripheral joint pain Read code for the hand, hip, knee, or foot, to reduce the potential

102   for selection bias in clinician coding. Patients were allocated to an index clinician, being the clinician

103   recording the first formally diagnosed (i.e. OA Read-coded) OA consultation in the baseline period

104   or, if none, the first peripheral joint pain coded consultation in the same period.

105   Outcome measures were the seven indicators of quality of care for OA in general practice recorded

106   in the EHR. These could be entered into the EHR as routinely-recorded data or captured through

107   the e-template. The identification and synthesis of appropriate quality indicators using a systematic

108   review and NICE 2008 guidelines has previously been reported [5,7,8]. The indicators are shown in

109   Table 1.

110   Achievement of prescribing and referral indicators (recorded prescription of topical NSAIDs or

111   paracetamol, and onward physiotherapy referral) were determined from data in the routinely-

112   recorded component of the EHR and were determined to have been achieved if they were recorded

113   within 14 days of any clinical OA consultation in the six-month period.

114   The e-template facilitated recording of achievement of indicators that are known to be poorly

115   captured in routinely-recorded data [5]: (i) assessment of pain and function, (ii) provision or

116   consideration of OA information, exercise advice, and weight loss advice, (iii) consideration of

117   paracetamol or topical NSAID and (iv) consideration of physiotherapy referral. The entry of a code

118   for clinical OA for a patient aged ≥45 years triggered the e-template [5]. The clinicians could

119   complete the e-template at any point throughout the consultation and could choose to complete

120   all, some, or none of the e-template. The e-template has been endorsed by NICE to facilitate

121   enhanced uptake of quality standards [9].

122   Data from the EHR (derived from both routinely-recorded data and the e-template) were

123   amalgamated within the relevant quality indicator. For example, consideration of paracetamol and

124   topical NSAIDs (entered using e-template) was combined with actual prescription of these agents

125   (routinely-recorded data). Outcomes (Table 1) were dichotomous for pain and function

126   assessments. For all other indicators, the possibilities were for the indicator to be *achieved*,

127   *considered* (without record of having been delivered), or *not considered*. There is evidence that

128   weight recording is more common in people who are overweight compared to those who are not

129   [10]. To minimise the effect of missing data and to preserve the ability of the model to identify

130   people who needed weight loss advice but were not recorded as receiving it, any patient recorded

131   as being of normal weight or who did not have a weight recorded was allocated to *considered* for

132   weight loss advice.

133 We investigated how patterns of care based on the quality indicators were associated with other

134 OA care processes, recorded in the routine EHR within 14 days of any clinical OA consultation:

135 prescriptions for oral NSAIDs and opioids, and relevant X-rays (hand, hip knee, or foot).

136 Factors potentially associated with patterns of quality of care that were considered were: patient

137 age, gender, body mass index (BMI), the site of clinical OA, whether patients had multiple or a

138 single consultation for clinical OA within the six-month time period, whether the patient was a new

139 consulter (no clinical OA consultations within the previous 12 months) and total morbidity. Total

140 morbidity was measured by a count of British National Formulary (BNF) subchapters from which

141 prescriptions had been issued in the previous 12 months [11]. A proxy measure of OA workload for

142 the patients' index clinician was determined by dichotomising the number of index clinical OA

143 consultations at the median value (14) across clinicians.

144 *Statistical analysis*

145 Latent class analysis (LCA) was used to cluster patients into groups based on recorded achievement

146 of the seven quality indicators. All patients within a cluster should have similar recorded care for

147 their OA or joint pain, but care should differ between patients belonging to different clusters [12].

148 Latent class models were fitted, beginning with a one-cluster model where all the patients were

149 assumed to have been given the same pattern of treatment of OA, up to a seven-cluster model. To

150 determine the optimum number of clusters, we considered the Bayesian Information Criterion (BIC,

151 whereby the lowest BIC indicated the best model) with the size of each cluster, and the

152 interpretability of the model. Posterior probabilities (PP) for a patient (the probabilities of that

153 patient belonging to each of the clusters within the model) were identified. The cluster that had the

154 largest PP for a patient was the cluster that patient was assigned to. We used the mean PP for

155 patients allocated to each cluster to measure cluster separation; a mean PP of more than 0.7

156 indicated that the patients were clearly assigned to that specific cluster [13].

157 Using a two-level (patient within index clinician) multinomial multilevel logistic regression,

158 associations between the patient and clinician-level covariates and cluster membership were

159 estimated and reported as relative risk ratios (RRR) with 95% confidence intervals (CI). We also

160 used chi-squared tests to compare between clusters on levels of pain and functional limitation

161 (none, mild, moderate, severe) as recorded in the e-template.

162 Statistical analysis was performed using R studio version 3.3.0, and MLwiN version 2.35 for

163 Windows.

164 **Results**

165 During the six-month period, 1724 patients consulted with a recorded clinical OA code and

166 triggered the e-template. All were included in the analysis. 1014 (59%) of these were female, mean

167 age was 66.1 years (SD: 11.9) and 582 (34%) patients were recorded with a diagnosis of OA rather

168 than peripheral joint pain.

169 As previously reported [5], pain (63%) and function (62%) assessment were the most commonly

170 achieved indicators. Recorded provision of OA information (44%), and exercise advice (45%) were

171 achieved in under half of patients, and weight loss advice in less than a third of patients (31%). 609

172 (35%) patients were prescribed paracetamol or topical NSAIDs. A referral for physiotherapy was

173 made in 7% of patients.

174 Table 2 shows the goodness-of-fit statistics for the LCA models with one to seven clusters. The four-

175 cluster model gave the lowest BIC, and each of the clusters in the three-, four-, and five-cluster

176 models had a mean PP for patients belonging to that cluster above 0.83. In the three-cluster model

177   the smallest cluster size was 430 (25%), in the four-cluster model it was 184 (11%) and the five-

178   cluster model had a smallest cluster size of 142 (8%). Based on the cluster sizes, goodness-of-fit

179   statistics, and interpretability, the four-cluster model was chosen as the optimal model.

180   Table 3 shows the probability of recorded receipt of each of the seven quality indicators for

181   patients allocated to each cluster. Patients in cluster 1 (*n*=659, 38%) had a high probability of having

182   pain and function assessment recorded (probabilities over 0.97) and of being given OA information

183   and exercise advice (probabilities over 0.93). Patients' care within this cluster was recorded as

184   having achieved a median of five indicators and considered for, but not achieved, a median of one

185   further indicator. Cluster 1 was therefore labelled as having a *High* level of recorded quality of care.

186   Cluster 2 (*n*=184, 11%; *Moderate*) had a high probability of pain and function assessment

187   (probabilities over 0.95) and of consideration for (but not receipt of) physiotherapy and topical

188   NSAID or paracetamol. They also had a high probability of being given or considered for OA

189   information and exercise advice. Their recorded care achieved a median of three indicators and

190   they were considered for care relating to a median of three further indicators. Cluster 3 (*n*=286,

191   17%; *Low*) had a high probability of pain and function assessment (probabilities over 0.87), and

192   were likely to be prescribed or considered for paracetamol or topical NSAIDs but generally were not

193   recorded as receiving or being considered for other indicators (received a median of three

194   processes and considered for a median of one further). Cluster 4 (*n*=595, 35%; *None*) had low

195   probabilities of a record of receiving or being considered for any indicator (received and considered

196   median zero indicators).

197   Supplementary Table 1 compares the number of people in each cluster who were expected, based

198   on the model, to receive each care process (identified by the indicators) and the number actually

199 recorded as receiving them. Differences between observed and expected values were small and

200 generally related to distinguishing between care received compared to care considered.

201 Patient and clinician characteristics for each cluster are shown in Table 4 with results from the

202 multinomial model comparing clusters in Table 5. Compared to the *None* cluster, patients in the

203 *High* and *Moderate* clusters tended to consult with a clinician with a higher OA workload, consult

204 multiple times, and have less total morbidity (Table 5). The patients with *High* level of recorded

205 care were more likely to have diagnosed OA (adjusted RRR 1.81, 95% CI 1.41, 2.32) and less likely to

206 have hand or foot clinical OA than patients in the *None* cluster, whilst patients in the *Moderate*

207 cluster were less likely to have diagnosed OA (RRR 0.55, 95% CI 0.35, 0.85) or be overweight (RRR

208 0.57, 95% CI 0.39, 0.85), but more likely to have clinical OA in multiple sites (RRR 1.89, 95% CI 0.99,

209 3.59) than patients in the *None* cluster. Patients in the *Low* cluster were less likely than patients in

210 the *None* cluster to have a single consultation (RRR 0.45, 95% CI 0.34, 0.60), have clinical OA in the

211 foot (RRR 0.25, 95% CI 0.13, 0.51), or have multimorbidity.

212 Those in the *High* cluster had slightly higher levels of opioid prescription (36%; chi-squared test,

213 *p*=0.06), oral NSAID prescription (20%; *p*=0.01), and recorded X-rays (22%; *p*<0.01) than patients in

214 the other clusters, although differences between the *High* and *Low* clusters, in particular, were

215 small (Table 6).

216 In those with a record of a pain assessment, patients in the *High* cluster were more likely to have

217 recorded moderate or severe pain (70% vs 57% in the *Moderate* cluster and 64% in the *Low*

218 cluster). The same pattern was seen for functional limitation although differences between clusters

219 were smaller (Table 6).

Discussion

221 This study has identified four patterns of recorded primary care management of OA based on

222 previously identified quality indicators of care. Just over a third of patients consulting for clinical OA

223 had recorded care meeting the majority of quality indicators. Another third were not recorded as

224 having received or been considered for any of these quality indicators. Factors associated with

225 higher recorded quality of care included receiving an OA diagnosis, OA in the knee or hip rather

226 than foot or hand, lower total morbidity burden, multiple consultations for clinical OA, and initial

227 consultation with a clinician who was recorded as seeing more than the median number of OA

228 patients. Previous evidence has demonstrated that guidelines for treatment of OA within primary

229 care are not consistently adhered to [14-16]. The way in which receipt of different recommended

230 care processes for OA are grouped within patients has not previously been investigated. In our

231 study, 38% of the patients were recorded as having received a relatively large number of quality

232 indicators and could be regarded as a group achieving the closest to optimal care based on these

233 indicators (the *High* group). Care for members of two clusters (*Moderate* and *Low)* achieved some

234 quality indicators overall but can be distinguished by the fact that information, advice (exercise,

235 weight loss) and physiotherapy were more likely to be considered in the *Moderate* cluster than the

236 *Low*. A third of patients were in the *None* cluster which demonstrated the weakest recorded quality

237 of care with the majority of this group lacking recorded achievement or consideration of any

238 indicator. The patients in the cluster with the best recorded care (*High*) were also more likely to

239 receive other elements of care such as oral NSAIDs and referral for X-ray. NICE does not

240 recommend routine use of X-ray for OA diagnosis and suggests that opioids and oral NSAIDS should

241 be used only if topical NSAIDs and paracetamol do not relieve pain [3]. The greater use of these

242 approaches in the *High* cluster may reflect worse severity of OA and this cluster did have slightly

243 higher levels of clinician-recorded pain and functional limitation than those in the *Moderate* and

244 *Low* clusters. While one hypothesis may be that patients in the *High* cluster are given all possible

245 care elements, this is unlikely to be the case as differences between clusters on the non-quality

246 indicator elements of care were generally small, and most patients in the *High* cluster were not in

247 receipt of these non-recommended approaches.

248 It is possible that the clinicians treating those in the *High* cluster were more engaged with, or more

249 confident in managing OA. Confidence in OA management could be associated with confidence in

250 OA diagnosis, which may explain the increased use of OA Read codes in these patients. Conversely,

251 where OA Read codes were not given there may have been uncertainty about both diagnosis and

252 management. Previous qualitative observational research of primary care consultations has

253 identified confusion about the construct of OA, with family doctors tending not to use the term

254 'osteoarthritis' with patients but instead, normalising symptoms [17]. A formal diagnosis of OA,

255 delivered explicitly, may be needed for holistic components of care such as patient education and

256 self-management support to be offered [5,17]. Patients with greater morbidity received a lower

257 recorded quality of care and this may be because they were (perhaps erroneously) considered less

258 suitable for non-pharmacological and relatively safe pharmacological options. It is also possible that

259 OA was given lower priority compared to their other problems [17,18]. Patients with foot (and to

260 some extent hand) OA may also have been particularly susceptible to lower levels of recorded

261 quality of care and this site has been less well-investigated with regard to effective interventions

262 [19,20].

263 This is the first study known to the authors which examines patterns of quality of care of chronic

264 conditions such as OA. Other analyses of recorded quality of care for OA have reported some

265 influences on individual process measures. Broadbent et al. identified older age as being associated

266 with reduced information provision but increased initial use of paracetamol and, where an oral

267   NSAID was prescribed, greater first-use of ibuprofen or a COX-2 selective NSAID; female sex was

268   associated with increased information provision; severe OA was associated with increased pain and

269   function assessment in the previous year [21]. Unlike in this analysis, Min et al. identified an

270   association between multimorbidity (using a count of conditions) and better quality of care

271   amongst vulnerable elders, some of whom had OA [22].

272   This study has important strengths. The study population was large and the practices were diverse

273   with respect to urbanisation, staffing, deprivation, and size of registered population, implying good

274   generalisability. Prescription recording is likely to be near-complete since most prescribing is

275   electronic and use of the e-template mitigates against missing data from patients using over-the-

276   counter pharmacological approaches. The e-template also facilitates enhanced data collection in

277   general practice without incurring biases such as social desirability. LCA uses probabilistic modelling

278   and finite mixture distributions to collect participants into clusters, which is a different method to

279   traditional clustering techniques (e.g. cluster analysis). Given this, LCA should produce a lower

280   misclassification rate and better statistical criteria for investigating model fit [23]. Whilst there was

281   variation in quality of care between clinicians and practices [5], clustering effects of patients within

282   clinicians was adjusted for through the multilevel model. There are some limitations in this analysis.

283   Due to the inherent nature of EHR studies, the data extracted is a function of both the individual

284   clinician's clinical and recording behaviours. It is therefore possible that some patients were

285   misclassified as the lack of a record of a care process does not conclusively demonstrate that it did

286   not occur. Compared to prescription recording, it is less certain how well-recorded referrals are.

287   However, despite the limitations of EHR data, the differences in levels of prescribed analgesia

288   between the clusters suggests there were real differences in care between the four clusters

289   identified. Conversely, patients may have been coded as receiving some elements of care without

290 this necessarily having been conducted in a comprehensive or meaningful way. Triangulation of

291 medical record indicators with patient-reported indicators would be needed to evaluate this

292 further. Our assumption that those without a weight recorded were considered for weight loss

293 advice was based on the increased likelihood of a weight recording if a patients appears overweight

294 [10] but will have over-estimated the proportion of patients considered for weight loss advice.

295 However, over 80% of patients did have a weight record. The association between multiple

296 consultations for OA and clusters with higher recorded quality of care may reflect greater

297 opportunity to provide and record care but may also have reflected a greater disease severity and

298 healthcare need. Although we considered comorbidities, previous research has identified that OA

299 may be discussed in complex consultations about multiple problems [17] and the length of time

300 discussing OA in a consultation would likely be an important influence on the level of recorded care.

301 It is also possible that those with recorded peripheral joint pain rather than recorded OA may not

302 have OA, particularly in the foot [24]. The e-template itself was previously found to be associated

303 with increased prescription of paracetamol and topical NSAIDs and so the patterns of care recorded

304 may not be generalisable to practices not using the e-template [5].

305 Promotion of core interventions (information, exercise, and weight loss advice), alongside

306 appropriate use of the relatively safe pharmacological options, remains an important strategy in the

307 primary care management of OA but many patients receive few or none of these. This is particularly

308 true for patients with higher levels of morbidity, or hand or foot OA. Whilst there is substantial

309 variation in recorded care of OA, high quality care appears feasible given we found that over a third

310 of patients with OA were recorded as receiving most core recommendations. A structured annual

311 review for people with OA [25] as recommended by NICE [9] may help, possibly nurse-led,

312 integrated, where appropriate, into a multimorbidity review. However, barriers to providing and

313 recording high quality care still need to be identified and mechanisms need to be explored to

314 ensure appropriate delivery of care to all patients.

315 **Acknowledgements**

322 **Author statement**

323 HJ and LB performed the analysis and drafted and revised the paper. KPJ and JJE developed the

324 analysis plan, cleaned the data, and drafted and revised the paper; KSD is PI for the study, led the

325 design of the MOSAICS study, and revised the paper; EC, ZP and AF were involved in the

326 interpretation of the findings and revised the paper. All authors have approved the final version.

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Competing interests

Data access statement

349 The Centre has established data sharing arrangements to support joint publications and other

350 research collaborations. Applications for access to anonymised data from our research databases

351 are reviewed by the Centre's Data Custodian and Academic Proposal (DCAP) Committee and a

352 decision regarding access to the data is made subject to the NRES ethical approval first provided for

353 the study and to new analysis being proposed. Further information on our data sharing procedures

354 can be found on the Centre's website

355 (http://www.keele.ac.uk/pchs/publications/datasharingresources/) or by emailing the Centre's

356 data manager (primarycare.datasharing@keele.ac.uk).

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Table 1: Quality Indicators and categories used for latent class analysis

Quality Indicator	Categories	Definition
Pain Assessed	Assessed	Recorded level of pain[a]
	Not Assessed	No entry recorded[a]
Function Assessed	Assessed	Recorded level of function[a]
	Not Assessed	No entry recorded[a]
OA Information	Given	Recorded written or verbal[a]
	Considered, but Not Given	Recorded not appropriate[a]
	Not Considered	No entry recorded[a]
Exercise Advice	Given	Recorded written or verbal[a]
	Considered, but Not Given	Recorded not appropriate[a]
	Not Considered	No entry recorded[a]
Weight loss Advice[c]	Given	Recorded written or verbal[a]
	Considered, but Not Given	Recorded not appropriate[a]
	Not Considered	No entry recorded[a]
Paracetamol or Topical NSAID	Prescribed	Either drug prescribed[b]
	Considered, but Not Prescribed	Neither drug prescribed but recorded tried, offered, patient declined, or not appropriate[a]
	Not Considered	Neither drug prescribed, recorded unknown or no entry recorded for both drugs[a]
Physiotherapy	Referred	Recorded referral[b]
	Considered, but Not Referred	No referral but recorded as offered, or not necessary or not appropriate[a]
	Not Considered	No referral, recorded not this time or no entry recorded[a]

[a] from e-template; [b] from routine records; [c] patients without a recorded BMI of ≥25 within the last 3 years were allocated to "Considered, but not given" category

Table 2: Latent class analysis goodness of fit statistics

Number of clusters	BIC	χ^2 goodness of fit	Population (%) of smallest cluster	Range of mean PP across clusters	*n* (%) with PP<0.7
1	20994.14	32978.08	1724 (100)	1.000	0 (0)
2	15160.57	3332.77	1071 (62)	0.992, 0.987	3 (<1)
3	14715.82	1727.74	430 (25)	0.906, 0.991	138 (8)
4	14627.48	1522.28	184 (11)	0.848, 0.994	157 (9)
5	14661.55	809.88	142 (8)	0.830, 0.993	207 (12)
6	14699.79	733.23	112 (6)	0.754, 0.996	257 (15)
7	14771.09	818.78	22 (1)	0.701, 0.996	267 (15)

BIC: Bayesian Information Criterion; PP: posterior probability

Table 3: Conditional item response probabilities for the quality indicators for each cluster

		Overall	Cluster			
			High	*Moderate*	*Low*	*None*
			(*n*=659,	(*n*=184,	(*n*=286,	(*n*=595,
	Quality Indicators	*n* (%)	38%)	11%)	17%)	35%)
Pain	Assessed	1092 (63)	0.978	0.961	0.922	0.014
Assessment	Not Assessed	632 (37)	0.022	0.039	0.078	0.987
Function	Assessed	1070 (62)	0.981	0.955	0.873	0.000
Assessment	Not Assessed	654 (38)	0.019	0.045	0.127	1.000
OA	Given	764 (44)	0.930	0.463	0.319	0.001
Information	Considered, Not Given	85 (5)	0.009	0.330	0.011	0.000
	Not Considered	875 (51)	0.062	0.207	0.670	1.000
Exercise	Given	768 (45)	0.994	0.417	0.237	0.000
Advice	Considered, Not Given	96 (6)	0.007	0.313	0.067	0.000
	Not Considered	860 (50)	0.000	0.270	0.696	1.000
Weight	Given	536 (31)	0.593	0.115	0.089	0.000
Advice	Considered, Not Given	153 (9)	0.298	0.733	0.347	0.441
	Not Considered	1035 (60)	0.109	0.152	0.564	0.559
Topical	Prescribed	609 (35)	0.476	0.273	0.394	0.239
NSAID/	Considered, Not Prescribed	570 (33)	0.496	0.641	0.406	0.004
paracetamol	Not Considered	545 (32)	0.028	0.086	0.200	0.757
	Referred	124 (7)	0.111	0.037	0.101	0.032
Physiotherapy	Considered, Not Referred	532 (31)	0.559	0.732	0.080	0.000
	Not Considered	1068 (62)	0.330	0.230	0.819	0.968
Median count (IQR) Assessed/prescribed/given/referred			5 (4, 6)	3 (2, 3)	3 (2, 3)	0 (0, 1)
Median count (IQR) Considered			1 (1, 2)	3 (2, 4)	1 (0, 1)	0 (0, 1)

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Table 4: Patient and clinician characteristics for each cluster

		Total *n* (%)	Cluster			
			High (*n*=659)	*Moderate* (*n*=184)	*Low* (*n*=286)	*None* (*n*=595)
Age:	45-64	817	277 (34)	109 (13)	293 (43)	138 (17)
	65-74	442	213 (48)	20 (5)	144 (33)	65 (15)
	75-84	349	133 (38)	35 (10)	116 (33)	65 (19)
	85+	116	36 (31)	20 (17)	42 (36)	18 (6)
Gender:	Male	710	286 (40)	68 (10)	113 (16)	243 (34)
	Female	1014	373 (37)	116 (11)	173 (17)	352 (35)
BMI category:						
	Normal	315	111 (35)	54 (17)	48 (15)	102 (32)
	Overweight	1080	471 (44)	83 (8)	193 (18)	333 (31)
	Not recorded	329	77 (23)	47 (14)	45 (14)	160 (49)
Recorded joint pain only		1142	366 (32)	148 (13)	207 (18)	421 (37)
OA diagnosis		582	293 (50)	36 (6)	79 (14)	174 (30)
Site of OA:						
	Knee	855	359 (42)	80 (9)	149 (17)	267 (31)
	Hip	363	135 (37)	41 (11)	68 (19)	119 (33)
	Foot	125	30 (24)	15 (12)	10 (8)	70 (56)
	Hand	152	33 (22)	25 (16)	31 (20)	63 (41)
	Unspecified	99	30 (30)	8 (8)	16 (16)	45 (46)
	Multiple	130	72 (55)	15 (12)	12 (9)	31 (24)
Morbidity load[a]:						
BNF count	0-4	485	156 (32)	68 (14)	89 (18)	172 (36)
	5-9	578	240 (42)	56 (10)	99 (17)	183 (32)
	10+	661	263 (40)	60 (9)	98 (15)	240 (36)
Clinician OA workload[b]:						
Below the median		197	41 (21)	16 (8)	36 (18)	104 (53)
Above the median		1527	618 (41)	168 (11)	250 (16)	491 (32)
Median (IQR) no. of OA consultations[b]		1 (0, 1)	1 (1, 2)	1 (1, 2)	1 (1, 2)	1 (1, 1)
OA consultations[b]:						
	Multiple	532	250 (47)	63 (12)	99 (19)	120 (23)
	Single	1192	409 (34)	121 (10)	187 (16)	475 (40)
Consulter status:						
	Repeat	566	232 (41)	53 (9)	84 (15)	197 (35)
	New[c]	1158	427 (37)	131 (11)	202 (17)	398 (34)

[a] Number of BNF sections from which prescription was made in previous 12 months; [b] during six month period; [c] no clinical OA consultations within the previous 12 months

Table 5: Associations of patient and clinician characteristics with cluster membership

n= 1724		*High* vs *None* RRR[a] (95% CI)	*Moderate* vs *None* RRR[a] (95% CI)	*Low* vs *None* RRR[a] (95% CI)
Age:	45-64	1	1	1
	65-74	1.41 (1.07, 1.84)	0.45 (0.27, 0.74)	0.97 (0.69, 1.37)
	75-84	1.13 (0.83, 1.52)	1.02 (0.65, 1.60)	1.42 (0.99, 2.05)
	85+	0.91 (0.56, 1.47)	1.56 (0.85, 2.89)	1.24 (0.69, 2.23)
Gender:	Male	1	1	1
	Female	0.86 (0.69, 1.07)	1.03 (0.75, 1.43)	1.04 (0.80, 1.36)
BMI category:	Normal	1	1	1
	Overweight	1.20 (0.91, 1.60)	0.57 (0.39, 0.85)	1.33 (0.93, 1.90)
	Not recorded	0.39 (0.27, 0.56)	0.52 (0.33, 0.81)	0.52 (0.33, 0.82)
Recorded joint pain only		1	1	1
OA diagnosis		1.81 (1.41, 2.32)	0.55 (0.35, 0.85)	0.93 (0.68, 1.29)
Site of OA:	Knee	1	1	1
	Hip	0.86 (0.66, 1.14)	1.14 (0.76, 1.71)	1.04 (0.75, 1.44)
	Foot	0.38 (0.24, 0.60)	0.73 (0.39, 1.36)	0.25 (0.13, 0.51)
	Hand	0.45 (0.30, 0.70)	1.18 (0.70, 1.98)	0.88 (0.56, 1.39)
	Unspecified	0.48 (0.30, 0.80)	0.85 (0.38, 1.90)	0.74 (0.41, 1.34)
	Multiple	1.13 (0.75, 1.74)	1.89 (0.99, 3.59)	0.65 (0.34, 1.24)
Morbidity load[b]:				
BNF count	0-4	1	1	1
	5-9	0.95 (0.71, 1.26)	0.74 (0.50, 1.11)	0.75 (0.54, 1.06)
	10+	0.64 (0.47, 0.87)	0.55 (0.35, 0.86)	0.50 (0.35, 0.73)
Clinician OA workload[c]:				
Below the median		1	1	1
Above the median		2.90 (1.98, 4.25)	2.32 (1.33, 4.03)	1.46 (0.98, 2.18)
OA consultations[c]:				
Multiple		1	1	1
Single		0.43 (0.34, 0.54)	0.47 (0.33, 0.66)	0.45 (0.34, 0.60)
Consulter status:	Repeat	1	1	1
	New[d]	1.12 (0.89, 1.41)	1.09 (0.76, 1.55)	1.18 (0.88, 1.59)

[a] Relative risk ratio from multilevel multinomial regression (patients within initial clinician seen) adjusted for all presented covariates, *None* cluster is reference; [b] Number of BNF sections from which prescription was made in previous 12 months; [c] during six month period; [d] no clinical OA consultations within the previous 12 month

Table 6: Use of management processes other than those used as quality indicators, and recorded severity of pain and functional limitation, by cluster

n (column %)	Total n (%)	High (n=659)	Moderate (n=184)	Low (n=286)	None (n=595)	p-value[a]
Opioid Prescribed	557 (33)	236 (36)	54 (29)	94 (33)	173 (29)	0.06
Oral NSAID Prescribed	284 (17)	130 (20)	21 (11)	49 (17)	84 (14)	0.01
X-ray Requested	263 (15)	142 (22)	30 (16)	52 (18)	39 (7)	<0.01
n with pain record	1092	645	177	263	7	0.001[b]
No pain	16 (1)	4 (<1)	7 (4)	4 (2)	1	
Mild pain	348 (32)	187 (29)	69 (39)	91 (35)	1	
Moderate pain	582 (53)	357 (55)	84 (47)	136 (52)	5	
Severe pain	146 (13)	97 (15)	17 (10)	32 (12)	0	
n with function record	1070	646	174	250	0	0.004[b]
No limitation	101 (9)	46 (7)	29 (16)	26 (10)	0	
Mild limitation	456 (43)	276 (43)	73 (42)	107 (43)	0	
Moderate limitation	427 (40)	277 (43)	57 (33)	93 (37)	0	
Severe limitation	86 (8)	47 (7)	15 (9)	24 (10)	0	

[a]χ^2 test, [b] excluding *None* cluster

Cluster

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title upload
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract upload
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	2-3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-5
Bias	9	Describe any efforts to address potential sources of bias	3
Study size	10	Explain how the study size was arrived at	N/A (sample size calculation was for the clinical outcomes reported elsewhere)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used	5-6

	to control for confounding	
	(*b*) Describe any methods used to examine subgroups and interactions	N/A
	(*c*) Explain how missing data were addressed	4
	(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
	(*e̲*) Describe any sensitivity analyses	N/A

Results			**Page**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 4
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	Table 3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 5
		(*b*) Report category boundaries when continuous variables were categorized	Table 4, 5
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Patterns of routine primary care for osteoarthritis in the UK:
a cross-sectional electronic health records study

SCHOLARONE™
Manuscripts

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1   **Patterns of routine primary care for osteoarthritis: a cross-sectional electronic health records**

2   **study**

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19   734719

20   Word count: 3424

21   Running title: Patterns of primary care for osteoarthritis

22 **Abstract**

23 **Objective**

24 To determine common patterns of recorded primary care for osteoarthritis (OA), and patient and

25 provider characteristics associated with the quality of recorded care.

26 **Design**

27 An observational study nested within a cluster-randomised controlled trial.

28 **Setting**

29 Eight UK general practices who were part of the Management of OSteoArthritis In ConsultationS

30 (MOSAICS) study.

31 **Participants**

32 Patients recorded as consulting within the eight general practices for clinical OA.

33 **Primary outcomes**

34 Achievement of seven quality indicators of care (pain/function assessment, information provision,

35 exercise/weight advice, analgesics, physiotherapy), recorded through an electronic template or

36 routinely-recorded in the electronic healthcare records, were identified for patients aged ≥45 years

37 consulting over a six-month period with clinical OA. Latent class analysis was used to cluster

38 patients based on care received. Clusters were compared on patient and clinician-level

39 characteristics.

40 **Results**

41 1724 patients (median by practice 183) consulted with clinical OA. Common patterns of recorded

42 quality care were: Cluster 1 (38%, *High*) received most quality indicators of care; Cluster 2 (11%,

43 *Moderate*) had pain and function assessment, and received or were considered for other indicators;

44 Cluster 3 (17%, *Low*) had pain and function assessment, and received or were considered for

45 paracetamol or topical NSAIDs; Cluster 4 (35%, *None*) had no recorded quality indicators. Patients

46 with higher levels of recorded care consulted a clinician who saw more OA patients, consulted

47 multiple times, and had less morbidity. Those in the *High* cluster were more likely to have recorded

48 diagnosed OA and have knee/hip OA.

49 **Conclusions**

50 Patterns of recorded care for OA fell into four natural clusters. Appropriate delivery of core

51 interventions and relatively safe pharmacological options for OA are still not consistently recorded

52 as provided in primary care. Further research to understand clinical recording behaviours and

53 determine potential barriers to quality care alongside effective training for clinicians is needed.

54 **Trial registration number**: ISRCTN06984617

55 **Keywords**

56 Osteoarthritis, primary care, quality indicators, latent class analysis

57 **Article summary**

58 • This paper describes a novel use of latent class analysis to identify patterns of primary care

59 for osteoarthritis (OA)

60 • The population studied was large and diverse, increasing generalisability, and based on a

61 broad definition of clinical OA to reduce selection bias

62 • The analysis used some quality indicators of care newly-implemented in practices through

63 an electronic template (pain/function assessment, information provision, exercise/weight

64 advice, analgesics, physiotherapy), which may have increased the recorded quality of care

65 compared to routine practice

66 • Four clusters of recorded care were identified: approximately one-third of patients had a

67 high probability of delivery of most care processes whilst another third had a low probability

68 of any such delivery. The remaining patients had a high probability of pain and function

69   assessment but were distinguished by the probability of delivery or consideration of other

70   aspects of care.

71   **Word count** 3582

72   **Introduction**

73   Osteoarthritis (OA) is a common reason for adults aged ≥45 years to consult primary care. Annually,

74   in the UK, 4% of such adults are recorded as consulting in general practice for diagnosed OA, with

75   an additional 8% recorded with joint pain likely to be attributable to OA [1]. Osteoarthritis is a

76   common reason for disability, and was ranked the 11th biggest cause of disability by the 2010

77   Global Burden of Disease (GBD) [2].

78   The UK National Institute for Health and Care Excellence (NICE) OA management guidelines

79   recommend core strategies of information provision, physical activity and exercise, and weight

80   management, supplemented with use of relatively safe pharmacological management strategies

81   (for example, topical non-steroidal anti-inflammatory drugs [NSAIDs]), as necessary [3].

82   Intensification of management should depend on response to these initial approaches. However,

83   there is evidence that patients diagnosed with OA do not receive care that is well aligned to

84   evidence-based recommendations and which may be overly dependent on pharmacological

85   methods [4].

86   We have previously identified variation between clinicians in recorded quality of individual

87   indicators of OA care [5]. However, patterns of OA care and factors linked with increased

88   probability of adherence to OA quality standards are less well-studied. Using electronic general

89   practice records data, the objectives of this study were to determine patterns of recorded primary

90   care for OA based on quality indicators, and to determine associations between higher-quality

91   recorded care and patient and clinician characteristics.

92   **Methods**

93   This analysis used data from the Management of OSteoArthritis In ConsultationS (MOSAICS) study

94   (Trial registration number ISRCTN06984617), approved by the North West Research Ethics

95 Committee, Cheshire (reference: 10/H1017/76) [6]. MOSAICS was a mixed-methods study, which

96 investigated the effect of a model consultation for clinical OA. It was set within eight general

97 practices in Cheshire, Shropshire and Staffordshire, UK. Practice eligibility has been reported

98 elsewhere [6]. The current analysis, reported in line with STROBE guidelines, used anonymised

99 information from the electronic health records (EHR) of these practices for the six-month baseline

100 period before randomisation of practices to intervention or control arms [6]. At the beginning of

101 the baseline period, a computerised template ("e-template", described below) was installed within

102 the EHR and all practices continued with otherwise usual care until the end of the baseline period.

103 The study population was all patients aged ≥45 years registered with the eight general practices

104 who consulted with clinical OA in the baseline six-month period. UK general practice utilises a

105 system of Read codes (similar in principle to the International Classification of Diseases codes) to

106 record symptoms, morbidities, and care processes [7]; within MOSAICS, clinical OA was defined as

107 either a recorded OA Read code or a peripheral joint pain Read code for the hand, hip, knee, or

108 foot, to reduce the potential for selection bias in clinician coding. Patients were allocated to an

109 index clinician, being the clinician recording the first formally diagnosed (i.e. OA Read-coded) OA

110 consultation in the baseline period or, if none, the first peripheral joint pain coded consultation in

111 the same period.

112 Outcome measures were the seven indicators of quality of care for OA in general practice recorded

113 in the EHR (Table 1). These could be entered into the EHR as routinely-recorded data or captured

114 through the e-template. The identification and synthesis of appropriate quality indicators using a

115 systematic review and NICE 2008 guidelines has previously been reported [5,8,9].

116 Achievement of prescribing and referral indicators (recorded prescription of topical NSAIDs or

117 paracetamol, and onward physiotherapy referral) were determined from data in the routinely-

118 recorded component of the EHR and were determined to have been achieved if they were recorded

119 within 14 days of any clinical OA consultation in the six-month period.

120 The e-template facilitated recording of achievement of indicators that are known to be poorly

121 captured in routinely-recorded data [5]: (i) assessment of pain and function, (ii) provision or

122 consideration of OA information, exercise advice, and weight loss advice, (iii) consideration of

123 paracetamol or topical NSAID and (iv) consideration of physiotherapy referral. The entry of a code

124 for clinical OA for a patient aged ≥45 years triggered the e-template. The design, interpretation, and

125 effects of the e-template have previously been reported [5]. The clinicians could complete the e-

126 template at any point throughout the consultation and could choose to complete all, some, or none

127 of the e-template. The e-template has been endorsed by NICE to facilitate enhanced uptake of

128 quality standards [10].

129 Data from the EHR (derived from both routinely-recorded data and the e-template) were

130 amalgamated within the relevant quality indicator. For example, consideration of paracetamol and

131 topical NSAIDs (entered using e-template) was combined with actual prescription of these agents

132 (routinely-recorded data). Outcomes (Table 1) were dichotomous for pain and function

133 assessments. For all other indicators, the possibilities were for the indicator to be *achieved*,

134 *considered* (without record of having been delivered), or *not considered*. There is evidence that

135 weight recording is more common in people who are overweight compared to those who are not

136 [11]. To minimise the effect of missing data and to preserve the ability of the model to identify

137 people who needed weight loss advice but were not recorded as receiving it, any patient recorded

138 as being of normal weight or who did not have a weight recorded was allocated to *considered* for

139 weight loss advice.

140 We investigated how patterns of care based on the quality indicators were associated with other

141 OA care processes, recorded in the routine EHR within 14 days of any clinical OA consultation:

142 prescriptions for oral NSAIDs and opioids, and relevant X-rays (hand, hip knee, or foot).

143 Factors potentially associated with patterns of quality of care that were considered were: patient

144 age, gender, body mass index (BMI), the site of clinical OA, whether patients had multiple or a

145 single consultation for clinical OA within the six-month time period, whether the patient was a new

146 consulter (no clinical OA consultations within the previous 12 months) and total morbidity. Total

147 morbidity was measured by a count of British National Formulary (BNF) subchapters from which

148 prescriptions had been issued in the previous 12 months [12]. A proxy measure of OA workload for

149 the patients' index clinician was determined by dichotomising the number of index clinical OA

150 consultations at the median value (14) across clinicians.

151 *Statistical analysis*

152 Latent class analysis (LCA) was used to cluster patients into groups based on recorded achievement

153 of the seven quality indicators. All patients within a cluster should have similar recorded care for

154 their OA or joint pain, but care should differ between patients belonging to different clusters [13].

155 Latent class models were fitted, beginning with a one-cluster model where all the patients were

156 assumed to have been given the same pattern of treatment of OA, up to a seven-cluster model. To

157 determine the optimum number of clusters, we considered the Bayes Information Criterion [14]

158 (BIC, whereby the lowest BIC indicated the best model) with the size of each cluster, and the

159 interpretability of the model. Posterior probabilities (PP) for a patient (the probabilities of that

160 patient belonging to each of the clusters within the model) were identified. The cluster that had the

161 largest PP for a patient was the cluster that patient was assigned to. We used the mean PP for

162 patients allocated to each cluster to measure cluster separation; a mean PP of more than 0.7

163 indicated that the patients were clearly assigned to that specific cluster [15].

164 Using a two-level (patient within index clinician) multinomial multilevel logistic regression,

165 associations between the patient and clinician-level covariates and cluster membership were

166 estimated and reported as relative risk ratios (RRR) with 95% confidence intervals (CI). We also

167 used chi-squared tests to compare between clusters on levels of pain and functional limitation

168 (none, mild, moderate, severe) as recorded in the e-template.

169 Statistical analysis was performed using R studio version 3.3.0, and MLwiN version 2.35 for

170 Windows.

171 **Results**

172 During the six-month period, 1724 patients (median per practice *n*=183) consulted with a recorded

173 clinical OA code and triggered the e-template. All were included in the analysis. 1014 (59%) of these

174 were female, mean age was 66.1 years (SD: 11.9) and 582 (34%) patients were recorded with a

175 diagnosis of OA rather than peripheral joint pain. Among consulters, 50% were recorded as having

176 clinical OA at the knee, 21% at the hip, and the remainder with ankle/foot, wrist/hand, multisite, or

177 unspecified clinical OA.

178 As previously reported [5], pain (63%) and function (62%) assessment were the most commonly

179 achieved indicators. Recorded provision of OA information (44%), and exercise advice (45%) were

180 achieved in under half of patients, and weight loss advice in less than a third of patients (31%). 609

181 (35%) patients were prescribed paracetamol or topical NSAIDs. A referral for physiotherapy was

182 made in 7% of patients.

183 Table 2 shows the goodness-of-fit statistics for the LCA models with one to seven clusters. The four-

184 cluster model gave the lowest BIC, and each of the clusters in the three-, four-, and five-cluster

185 models had a mean PP for patients belonging to that cluster above 0.83. In the three-cluster model

186 the smallest cluster size was 430 (25%), in the four-cluster model it was 184 (11%) and the five-

187 cluster model had a smallest cluster size of 142 (8%). Based on the cluster sizes, goodness-of-fit

188 statistics, and clinical interpretability, the four-cluster model was chosen as the optimal model.

189 Table 3 shows the probability of recorded receipt of each of the seven quality indicators for

190 patients allocated to each cluster. Patients in cluster 1 (*n*=659, 38%) had a high probability of having

191 pain and function assessment recorded (probabilities over 0.97) and of being given OA information

192 and exercise advice (probabilities over 0.93). Patients' care within this cluster was recorded as

193 having achieved a median of five indicators and considered for, but not achieved, a median of one

194 further indicator. Cluster 1 was therefore labelled as having a *High* level of recorded quality of care.

195 Cluster 2 (*n*=184, 11%; *Moderate*) had a high probability of pain and function assessment

196 (probabilities over 0.95) and of consideration for (but not receipt of) physiotherapy and topical

197 NSAID or paracetamol. They also had a high probability of being given or considered for OA

198 information and exercise advice. Their recorded care achieved a median of three indicators and

199 they were considered for care relating to a median of three further indicators. Cluster 3 (*n*=286,

200 17%; *Low*) had a high probability of pain and function assessment (probabilities over 0.87), and

201 were likely to be prescribed or considered for paracetamol or topical NSAIDs but generally were not

202 recorded as receiving or being considered for other indicators (received a median of three

203 processes and considered for a median of one further). Cluster 4 (*n*=595, 35%; *None*) had low

204 probabilities of a record of receiving or being considered for any indicator (received and considered

205 median zero indicators).

206 Table 4 compares the number of people in each cluster who were expected, based on the model, to

207 receive each care process (identified by the indicators) and the number actually recorded as

208 receiving them. Differences between observed and expected values were small and generally

209 related to distinguishing between care received compared to care considered. For example, in the

210 pain assessment domain, there was no difference between the counts of observed and expected

211 provision for the *High* and *Moderate* clusters, and a difference of only one patient in the *Low* and

212 *None* clusters; for OA information provision, this was observed more frequently than expected for

213 the *High* cluster (observed n=620 compared to 613 expected) but less frequently for the *Moderate*

214 (59 vs. 85) and *Low* (85 vs. 91) clusters.

215 Patient and clinician characteristics for each cluster are shown in Table 5 with results from the

216 multinomial model comparing clusters in Table 6. Compared to the *None* cluster, patients in the

217 *High* and *Moderate* clusters tended to consult with a clinician with a higher OA workload, consult

218 multiple times, and have less total morbidity (Table 6). The patients with *High* level of recorded

219 care were more likely to have diagnosed OA (adjusted RRR 1.81, 95% CI 1.41, 2.32) and less likely to

220 have hand or foot clinical OA than patients in the *None* cluster, whilst patients in the *Moderate*

221 cluster were less likely to have diagnosed OA (RRR 0.55, 95% CI 0.35, 0.85) or be overweight (RRR

222 0.57, 95% CI 0.39, 0.85), but more likely to have clinical OA in multiple sites (RRR 1.89, 95% CI 0.99,

223 3.59) than patients in the *None* cluster. Patients in the *Low* cluster were less likely than patients in

224 the *None* cluster to have a single consultation (RRR 0.45, 95% CI 0.34, 0.60), have clinical OA in the

225 foot (RRR 0.25, 95% CI 0.13, 0.51), or have multimorbidity.

226 Those in the *High* cluster had slightly higher levels of opioid prescription (36%; chi-squared test,

227 *p*=0.06), oral NSAID prescription (20%; *p*=0.01), and recorded X-rays (22%; *p*<0.01) than patients in

228 the other clusters, although differences between the *High* and *Low* clusters, in particular, were

229 small (Table 7).

230 In those with a record of a pain assessment, patients in the *High* cluster were more likely to have

231 recorded moderate or severe pain (70% vs 57% in the *Moderate* cluster and 64% in the *Low*

232 cluster). The same pattern was seen for functional limitation although differences between clusters

233 were smaller (Table 7).

234 **Discussion**

235 This study has identified four patterns of recorded primary care management of OA based on

236 previously identified quality indicators of care. Just over a third of patients consulting for clinical OA

237 had recorded care meeting the majority of quality indicators. Another third were not recorded as

238 having received or been considered for any of these quality indicators. Factors associated with

239 higher recorded quality of care included receiving an OA diagnosis, OA in the knee or hip rather

240 than foot or hand, lower total morbidity burden, multiple consultations for clinical OA, and initial

241 consultation with a clinician who was recorded as seeing more than the median number of OA

242 patients. Previous evidence has demonstrated that guidelines for treatment of OA within primary

243 care are not consistently adhered to [16-18]. The way in which receipt of different recommended

244 care processes for OA are grouped within patients has not previously been investigated. In our

245 study, 38% of the patients were recorded as having received a relatively large number of quality

246 indicators and could be regarded as a group achieving the closest to optimal care based on these

247 indicators (the *High* group). Care for members of two clusters (*Moderate* and *Low)* achieved some

248 quality indicators overall but can be distinguished by the fact that information, advice (exercise,

249 weight loss) and physiotherapy were more likely to be considered in the *Moderate* cluster than the

250 *Low*. A third of patients were in the *None* cluster which demonstrated the weakest recorded quality

251 of care with the majority of this group lacking recorded achievement or consideration of any

252 indicator. The patients in the cluster with the best recorded care (*High*) were also more likely to

253 receive other elements of care such as oral NSAIDs and referral for X-ray. NICE does not

254 recommend routine use of X-ray for OA diagnosis and suggests that opioids and oral NSAIDS should

255 be used only if topical NSAIDs and paracetamol do not relieve pain [3]. The greater use of these

256 approaches in the *High* cluster may reflect worse severity of OA and this cluster did have slightly

257 higher levels of clinician-recorded pain and functional limitation than those in the *Moderate* and

258 *Low* clusters. While one hypothesis may be that patients in the *High* cluster are given all possible

259 care elements, this is unlikely to be the case as differences between clusters on the non-quality

260 indicator elements of care were generally small, and most patients in the *High* cluster were not in

261 receipt of these non-recommended approaches.

262 It is possible that the clinicians treating those in the *High* cluster were more engaged with, or more

263 confident in managing OA. Confidence in OA management could be associated with confidence in

264 OA diagnosis, which may explain the increased use of OA Read codes in these patients. Conversely,

265 where OA Read codes were not given there may have been uncertainty about both diagnosis and

266 management. Previous qualitative observational research of primary care consultations has

267 identified confusion about the construct of OA, with family doctors tending not to use the term

268 'osteoarthritis' with patients but instead, normalising symptoms [19]. A formal diagnosis of OA,

269 delivered explicitly, may be needed for holistic components of care such as patient education and

270 self-management support to be offered [5,19]. Patients with greater morbidity received a lower

271 recorded quality of care and this may be because they were (perhaps erroneously) considered less

272 suitable for non-pharmacological and relatively safe pharmacological options. It is also possible that

273 OA was given lower priority compared to their other problems [19,20]. Patients with foot (and to

274 some extent hand) OA may also have been particularly susceptible to lower levels of recorded

275 quality of care and this site has been less well-investigated with regard to effective interventions

276 [21,22].

277 This is the first study known to the authors which examines patterns of quality of care of chronic

278 conditions such as OA. Other analyses of recorded quality of care for OA have reported some

279 influences on individual process measures. Broadbent et al. identified older age as being associated

280 with reduced information provision but increased initial use of paracetamol and, where an oral

281 NSAID was prescribed, greater first-use of ibuprofen or a COX-2 selective NSAID; female sex was

282 associated with increased information provision; severe OA was associated with increased pain and

283 function assessment in the previous year [23]. Unlike in this analysis, Min et al. identified an

284 association between multimorbidity (using a count of conditions) and better quality of care

285 amongst vulnerable elders, some of whom had OA [24].

286 This study has important strengths. The study population was large and the practices were diverse

287 with respect to urbanisation, staffing, deprivation, and size of registered population, implying good

288 generalisability. Prescription recording is likely to be near-complete since most prescribing is

289 electronic and use of the e-template mitigates against missing data from patients using over-the-

290 counter pharmacological approaches. The e-template also facilitates enhanced data collection in

291 general practice without incurring biases such as social desirability. LCA uses probabilistic modelling

292 and finite mixture distributions to collect participants into clusters, which is a different method to

293 traditional clustering techniques (e.g. cluster analysis). Given this, LCA should produce a lower

294 misclassification rate and better statistical criteria for investigating model fit [25]. Whilst there was

295 variation in quality of care between clinicians and practices [5], clustering effects of patients within

296 clinicians was adjusted for through the multilevel model. There are some limitations in this analysis.

297   Due to the inherent nature of EHR studies, the data extracted is a function of both the individual

298   clinician's clinical and recording behaviours. It is therefore possible that some patients were

299   misclassified as the lack of a record of a care process does not conclusively demonstrate that it did

300   not occur. Compared to prescription recording, it is less certain how well-recorded referrals are.

301   However, despite the limitations of EHR data, the differences in levels of prescribed analgesia

302   between the clusters suggests there were real differences in care between the four clusters

303   identified. Conversely, patients may have been coded as receiving some elements of care without

304   this necessarily having been conducted in a comprehensive or meaningful way. Triangulation of

305   medical record indicators with patient-reported indicators would be needed to evaluate this

306   further. Our assumption that those without a weight recorded were considered for weight loss

307   advice was based on the increased likelihood of a weight recording if a patients appears overweight

308   [11] but will have over-estimated the proportion of patients considered for weight loss advice.

309   However, over 80% of patients did have a weight record. The association between multiple

310   consultations for OA and clusters with higher recorded quality of care may reflect greater

311   opportunity to provide and record care but may also have reflected a greater disease severity and

312   healthcare need. Although we considered comorbidities, previous research has identified that OA

313   may be discussed in complex consultations about multiple problems [19] and the length of time

314   discussing OA in a consultation would likely be an important influence on the level of recorded care.

315   It is also possible that those with recorded peripheral joint pain rather than recorded OA may not

316   have OA, particularly in the foot [26]. The e-template itself was previously found to be associated

317   with increased prescription of paracetamol and topical NSAIDs and so the patterns of care recorded

318   may not be generalisable to practices not using the e-template [5].

319   Promotion of core interventions (information, exercise, and weight loss advice), alongside

320   appropriate use of the relatively safe pharmacological options, remains an important strategy in the

321   primary care management of OA but many patients receive few or none of these. This is particularly

322   true for patients with higher levels of morbidity, or hand or foot OA. Whilst there is substantial

323   variation in recorded care of OA, high quality care appears feasible given we found that over a third

324   of patients with OA were recorded as receiving most core recommendations. A lack of a systematic

325   approach to people with OA has previously been reported [27]. A structured annual review for

326   people with OA [28] as recommended by NICE [10] may help. This may possibly be nurse-led and

327   integrated, where appropriate, into a multimorbidity long-term condition review. However, causes

328   of variation in providing and recording of high quality care still need to be identified and

329   mechanisms need to be explored to ensure appropriate delivery of care to all patients.

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337   **Author statement**

338   HJ and LB performed the analysis and drafted and revised the paper. KPJ and JJE developed the

339   analysis plan, cleaned the data, and drafted and revised the paper; KSD is PI for the study, led the

340 design of the MOSAICS study, and revised the paper; EC, ZP and AF were involved in the

341 interpretation of the findings and revised the paper. All authors have approved the final version.

Competing interests

353 Prof. Jordan reports grants from National Institute for Health Research, grants from Arthritis

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361 submitted work; and Member of the NICE Osteoarthritis Guidelines Development Group CG 59

362 (2008) and CG 177 (2014). The other authors declare no competing interests.

363 **Data access statement**

364 The Centre has established data sharing arrangements to support joint publications and other

365 research collaborations. Applications for access to anonymised data from our research databases

366 are reviewed by the Centre's Data Custodian and Academic Proposal (DCAP) Committee and a

367 decision regarding access to the data is made subject to the NRES ethical approval first provided for

368 the study and to new analysis being proposed. Further information on our data sharing procedures

369 can be found on the Centre's website

370 (http://www.keele.ac.uk/pchs/publications/datasharingresources/) or by emailing the Centre's

371 data manager (primarycare.datasharing@keele.ac.uk).

372

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450   randomised controlled trial. BMC Fam Pract 2016;**17**(1):173.

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Table 1: Seven quality Indicators and categories used for latent class analysis

Quality Indicator	Categories	Definition
1. Pain assessed	Assessed	Recorded level of pain[a]
	Not assessed	No entry recorded[a]
2. Function assessed	Assessed	Recorded level of function[a]
	Not assessed	No entry recorded[a]
3. OA information	Given	Recorded written or verbal[a]
	Considered, but not given	Recorded not appropriate[a]
	Not considered	No entry recorded[a]
4. Exercise advice	Given	Recorded written or verbal[a]
	Considered, but not given	Recorded not appropriate[a]
	Not considered	No entry recorded[a]
5. Weight loss advice[c]	Given	Recorded written or verbal[a]
	Considered, but not given	Recorded not appropriate[a]
	Not considered	No entry recorded[a]
6. Paracetamol or topical NSAID	Prescribed	Either drug prescribed[b]
	Considered, but not prescribed	Neither drug prescribed but recorded tried, offered, patient declined, or not appropriate[a]
	Not considered	Neither drug prescribed, recorded unknown or no entry recorded for both drugs[a]
7. Physiotherapy	Referred	Recorded referral[b]
	Considered, but not referred	No referral but recorded as offered, or not necessary or not appropriate[a]
	Not considered	No referral, recorded not this time or no entry recorded[a]

[a] from e-template; [b] from routine records; [c] patients without a recorded BMI of ≥25 within the last 3 years were allocated to "Considered, but not given" category

Table 2: Latent class analysis goodness of fit statistics

Number of clusters	BIC	χ^2 goodness of fit	Population (%) of smallest cluster	Range of mean PP across clusters	n (%) with PP<0.7
1	20994.14	32978.08	1724 (100)	1.000	0 (0)
2	15160.57	3332.77	1071 (62)	0.992, 0.987	3 (<1)
3	14715.82	1727.74	430 (25)	0.906, 0.991	138 (8)
4	14627.48	1522.28	184 (11)	0.848, 0.994	157 (9)
5	14661.55	809.88	142 (8)	0.830, 0.993	207 (12)
6	14699.79	733.23	112 (6)	0.754, 0.996	257 (15)
7	14771.09	818.78	22 (1)	0.701, 0.996	267 (15)

BIC: Bayes Information Criterion; PP: posterior probability

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Table 3: Conditional item response probabilities for the quality indicators for each cluster

	Quality Indicators	**Overall** n (%)	**Cluster**			
			High (*n*=659, 38%)	*Moderate* (*n*=184, 11%)	*Low* (*n*=286, 17%)	*None* (*n*=595, 35%)
Pain Assessment	Assessed	1092 (63)	0.978	0.961	0.922	0.014
	Not Assessed	632 (37)	0.022	0.039	0.078	0.987
Function Assessment	Assessed	1070 (62)	0.981	0.955	0.873	0.000
	Not Assessed	654 (38)	0.019	0.045	0.127	1.000
OA Information	Given	764 (44)	0.930	0.463	0.319	0.001
	Considered, Not Given	85 (5)	0.009	0.330	0.011	0.000
	Not Considered	875 (51)	0.062	0.207	0.670	1.000
Exercise Advice	Given	768 (45)	0.994	0.417	0.237	0.000
	Considered, Not Given	96 (6)	0.007	0.313	0.067	0.000
	Not Considered	860 (50)	0.000	0.270	0.696	1.000
Weight Advice	Given	536 (31)	0.593	0.115	0.089	0.000
	Considered, Not Given	153 (9)	0.298	0.733	0.347	0.441
	Not Considered	1035 (60)	0.109	0.152	0.564	0.559
Topical NSAID/ paracetamol	Prescribed	609 (35)	0.476	0.273	0.394	0.239
	Considered, Not Prescribed	570 (33)	0.496	0.641	0.406	0.004
	Not Considered	545 (32)	0.028	0.086	0.200	0.757
Physiotherapy	Referred	124 (7)	0.111	0.037	0.101	0.032
	Considered, Not Referred	532 (31)	0.559	0.732	0.080	0.000
	Not Considered	1068 (62)	0.330	0.230	0.819	0.968
Median count (IQR) Assessed/prescribed/given/referred			5 (4, 6)	3 (2, 3)	3 (2, 3)	0 (0, 1)
Median count (IQR) Considered			1 (1, 2)	3 (2, 4)	1 (0, 1)	0 (0, 1)

Table 4: Expected number compared to observed for each category of indicators, by cluster

	Quality Indicators	Cluster											
		High (*n*=659, 38%)			Moderate (*n*=184, 11%)			Low (*n*=286, 17%)			None (*n*=595, 35%)		
		E	O	Δ	E	O	Δ	E	O	Δ	E	O	Δ
Pain Assessment	Assessed (*n*=1092, 63%)	645	645	0	177	177	0	264	263	1	8	7	1
	Not assessed (*n*=632, 37%)	14	14	0	7	7	0	22	23	-1	587	588	-1
Function Assessment	Assessed (*n*=1070, 62%)	646	646	0	176	174	2	250	250	0	0	0	0
	Not assessed (*n*=655, 38 %)	13	13	0	8	10	-2	36	36	0	595	595	0
OA Information	Given (*n*=764, 44%)	613	620	-7	85	59	26	91	85	6	0	0	0
	Considered, *not* given (*n*=85, 5%)	6	3	3	61	81	-20	3	1	2	0	0	0
	Not considered (*n*=875, 51%)	41	36	5	38	44	-6	192	200	-8	595	595	0
Exercise Advice	Given (*n*=768, 45%)	655	658	-3	77	53	24	68	57	11	0	0	0
	Considered, *not* given (*n*=96, 6%)	4	1	3	58	77	-19	19	18	1	0	0	0
	Not considered (*n*=860, 50%)	0	0	0	50	54	-4	199	211	-12	595	595	0
Weight Advice	Given (*n*=536, 31%)	391	370	21	21	20	1	26	22	4	0	0	0
	Considered, *not* given (*n*= 153, 9%)	196	213	-17	135	140	-5	99	99	0	262	262	0
	Not considered (*n*=1035, 60%)	72	76	-4	28	24	4	161	165	-4	333	333	0
Topical NSAID or paracetamol	Prescribed (*n*=609, 35%)	314	311	3	50	47	3	113	111	2	142	140	2
	Considered, *not* prescribed (*n*=570, 33%)	327	330	-3	118	119	-1	116	118	-2	2	3	-1
	Not considered (*n*=545, 32%)	18	18	0	16	18	-2	57	57	0	450	452	-2
Physiotherapy	Referred (*n*=124, 7%)	73	69	4	7	6	1	29	30	-1	19	19	0
	Considered, *not* referred (*n*=532, 31%)	369	371	-2	135	147	-12	23	14	9	0	0	0
	Not considered (*n*=1068, 62%)	218	219	-1	42	31	11	234	242	-8	576	576	0

E: expected number; **O**: observed number; **Δ**: difference

Table 5: Patient and clinician characteristics for each cluster

	Total *n* (%)	High (*n*=659)	Moderate (*n*=184)	Low (*n*=286)	None (*n*=595)
			Cluster		
Patient factors					
Age					
45-64	817	277 (34)	109 (13)	293 (43)	138 (17)
65-74	442	213 (48)	20 (5)	144 (33)	65 (15)
75-84	349	133 (38)	35 (10)	116 (33)	65 (19)
85+	116	36 (31)	20 (17)	42 (36)	18 (6)
Gender					
Male	710	286 (40)	68 (10)	113 (16)	243 (34)
Female	1014	373 (37)	116 (11)	173 (17)	352 (35)
BMI category:					
Normal	315	111 (35)	54 (17)	48 (15)	102 (32)
Overweight	1080	471 (44)	83 (8)	193 (18)	333 (31)
Not recorded	329	77 (23)	47 (14)	45 (14)	160 (49)
Diagnosis					
Recorded with joint pain only	1142	366 (32)	148 (13)	207 (18)	421 (37)
OA diagnosis	582	293 (50)	36 (6)	79 (14)	174 (30)
Site of OA:					
Knee	855	359 (42)	80 (9)	149 (17)	267 (31)
Hip	363	135 (37)	41 (11)	68 (19)	119 (33)
Foot	125	30 (24)	15 (12)	10 (8)	70 (56)
Hand	152	33 (22)	25 (16)	31 (20)	63 (41)
Unspecified	99	30 (30)	8 (8)	16 (16)	45 (46)
Multiple	130	72 (55)	15 (12)	12 (9)	31 (24)
Morbidity load[a]:					
BNF count 0-4	485	156 (32)	68 (14)	89 (18)	172 (36)
5-9	578	240 (42)	56 (10)	99 (17)	183 (32)
10+	661	263 (40)	60 (9)	98 (15)	240 (36)
Number of OA consultations[b]:					
Multiple	532	250 (47)	63 (12)	99 (19)	120 (23)
Single	1192	409 (34)	121 (10)	187 (16)	475 (40)
Median (IQR) no. of OA consultations[b]	1 (0, 1)	1 (1, 2)	1 (1, 2)	1 (1, 2)	1 (1, 1)
Consulter status:					
Repeat	566	232 (41)	53 (9)	84 (15)	197 (35)
New[c]	1158	427 (37)	131 (11)	202 (17)	398 (34)
Clinician factors					
Clinician OA workload[b]:					
Below the median	197	41 (21)	16 (8)	36 (18)	104 (53)
Above the median	1527	618 (41)	168 (11)	250 (16)	491 (32)

[a] Number of BNF subchapters from which prescription was made in previous 12 months; [b] during six month period; [c] no clinical OA consultations within the previous 12 months

Table 6: Associations of patient and clinician characteristics with cluster membership

n= 1724	*High* vs *None* RRR[a] (95% CI)	*Moderate* vs *None* RRR[a] (95% CI)	*Low* vs *None* RRR[a] (95% CI)
Patient factors			
Age			
45-64	1	1	1
65-74	1.41 (1.07, 1.84)	0.45 (0.27, 0.74)	0.97 (0.69, 1.37)
75-84	1.13 (0.83, 1.52)	1.02 (0.65, 1.60)	1.42 (0.99, 2.05)
85+	0.91 (0.56, 1.47)	1.56 (0.85, 2.89)	1.24 (0.69, 2.23)
Gender			
Male	1	1	1
Female	0.86 (0.69, 1.07)	1.03 (0.75, 1.43)	1.04 (0.80, 1.36)
BMI category			
Normal	1	1	1
Overweight	1.20 (0.91, 1.60)	0.57 (0.39, 0.85)	1.33 (0.93, 1.90)
Not recorded	0.39 (0.27, 0.56)	0.52 (0.33, 0.81)	0.52 (0.33, 0.82)
Diagnosis			
Recorded with joint pain only	1	1	1
OA diagnosis	1.81 (1.41, 2.32)	0.55 (0.35, 0.85)	0.93 (0.68, 1.29)
Site of OA			
Knee	1	1	1
Hip	0.86 (0.66, 1.14)	1.14 (0.76, 1.71)	1.04 (0.75, 1.44)
Foot	0.38 (0.24, 0.60)	0.73 (0.39, 1.36)	0.25 (0.13, 0.51)
Hand	0.45 (0.30, 0.70)	1.18 (0.70, 1.98)	0.88 (0.56, 1.39)
Unspecified	0.48 (0.30, 0.80)	0.85 (0.38, 1.90)	0.74 (0.41, 1.34)
Multiple	1.13 (0.75, 1.74)	1.89 (0.99, 3.59)	0.65 (0.34, 1.24)
Morbidity load[b]:			
BNF count 0-4	1	1	1
5-9	0.95 (0.71, 1.26)	0.74 (0.50, 1.11)	0.75 (0.54, 1.06)
10+	0.64 (0.47, 0.87)	0.55 (0.35, 0.86)	0.50 (0.35, 0.73)
Number of OA consultations[c]			
Multiple	1	1	1
Single	0.43 (0.34, 0.54)	0.47 (0.33, 0.66)	0.45 (0.34, 0.60)
Consulter status			
Repeat	1	1	1
New[d]	1.12 (0.89, 1.41)	1.09 (0.76, 1.55)	1.18 (0.88, 1.59)
Clinician factors			
Clinician OA workload[c]			
Below the median	1	1	1
Above the median	2.90 (1.98, 4.25)	2.32 (1.33, 4.03)	1.46 (0.98, 2.18)

[a] Relative risk ratio from multilevel multinomial regression (patients within initial clinician seen) adjusted for all presented covariates, *None* cluster is reference; [b] Number of BNF subchapters from which prescription was made in previous 12 months; [c] during six month period; [d] no clinical OA consultations within the previous 12 month

Table 7: Use of management processes other than those used as quality indicators, and recorded severity of pain and functional limitation, by cluster

| n (column %) | Total n (%) | Cluster | | | | p-value[a] |
		High (n=659)	Moderate (n=184)	Low (n=286)	None (n=595)	
Opioid Prescribed	557 (33)	236 (36)	54 (29)	94 (33)	173 (29)	0.06
Oral NSAID Prescribed	284 (17)	130 (20)	21 (11)	49 (17)	84 (14)	0.01
X-ray Requested	263 (15)	142 (22)	30 (16)	52 (18)	39 (7)	<0.01
n with pain record	1092	645	177	263	7	0.001[b]
No pain	16 (1)	4 (<1)	7 (4)	4 (2)	1	
Mild pain	348 (32)	187 (29)	69 (39)	91 (35)	1	
Moderate pain	582 (53)	357 (55)	84 (47)	136 (52)	5	
Severe pain	146 (13)	97 (15)	17 (10)	32 (12)	0	
n with function record	1070	646	174	250	0	0.004[b]
No limitation	101 (9)	46 (7)	29 (16)	26 (10)	0	
Mild limitation	456 (43)	276 (43)	73 (42)	107 (43)	0	
Moderate limitation	427 (40)	277 (43)	57 (33)	93 (37)	0	
Severe limitation	86 (8)	47 (7)	15 (9)	24 (10)	0	

[a] χ^2 test, [b] excluding *None* cluster

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title upload
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract upload
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	2-3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-5
Bias	9	Describe any efforts to address potential sources of bias	3
Study size	10	Explain how the study size was arrived at	N/A (sample size calculation was for the clinical outcomes reported elsewhere)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used	5-6

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	to control for confounding	
	(*b*) Describe any methods used to examine subgroups and interactions	N/A
	(*c*) Explain how missing data were addressed	4
	(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
	(*e*) Describe any sensitivity analyses	N/A

Results			**Page**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 4
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	Table 3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 5
		(*b*) Report category boundaries when continuous variables were categorized	Table 4, 5
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.